An Analysis of Closure Policy under Alternative Regulatory Structures

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Abstract

The author develops a theoretical model of bank closure. The regulatory decision about bank failure consists of two parts: whether to close and how to close. Assuming that the closure decision is credible, the welfare implications of two resolution regimes are considered. In one case, a *meta-regulator* supervises, closes, and resolves failed banks using an ex post efficient criterion. In the other case, a supervisor closes the bank while a deposit insurer resolves the closure on the basis of least cost. The bank chooses the riskiness of its loan portfolio in response to the announced policy. The supervisor can limit risk-shifting incentives of banks ex ante by raising capital requirements. The cost of this decision is a misallocation of economic resources, since some welfare-enhancing projects are abandoned. Market discipline is determined both exogenously, by the level of uninsured depositors, and endogenously, by the regime and capital requirements chosen. Least costly resolution weakly dominates an ex post efficient resolution decision when market discipline is present. Neither mechanism outperforms when reliant on capital regulation in the absence of market discipline.

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1. Introduction

This paper describes a theoretical model of bank closure in order to explore the trade-offs presented by different institutional arrangements. In many countries, there are multiple regulatory agencies that oversee the activities of deposit-taking institutions (DTIs). In Canada, for example, the Office of the Superintendent of Financial Institutions (OSFI) is responsible for prudential supervision, while the Canadian Deposit Insurance Corporation (CDIC) is responsible for management of the deposit insurance fund and the resolution decision for a failed DTI. Multiple agencies, however, are by no means the rule.[1] This paper will examine the costs and benefits of separating regulatory agency responsibilities as opposed to a consolidated approach, but solely in the context of closure and resolution policy.

There is no clear empirical evidence on which institutional structure works best.[2] Likewise, the theoretical literature has not addressed the merits of separation between domestic prudential supervision and deposit insurance management. Some papers examine the choice of delegation of supervisory powers between the central bank and the deposit insurer (e.g., Repullo 2002, Kahn and Santos 2001). Others address whether a central bank should supervise or *outsource* (Goodhart 2000). Each of these papers models both agencies as self-serving entities that wish to limit their loss exposure, and then asks where the supervisory power should reside.

This paper takes a different approach and considers whether a benevolent supervisory agency should resolve a failed bank or a self-serving deposit insurer. In the former case, there is a single *meta-regulator* that performs regulatory functions; in the latter, there are two separate agencies controlling the closure and resolution decision.

This framework contains two unmodelled factors that affect the trade-offs between regulatory regimes: the bank's loan portfolio quality, and the amount of uninsured deposits on a bank's balance sheet. Once the regulatory regime and capital requirements are set, a bank must choose whether to exit. Banks that have not exited choose between a risky or riskless loan portfolio. If the bank has a poor-quality loan portfolio, it is more likely to exit. The incentive to exit increases further if the supervisor has imposed harsh capital requirements.

If the bank remains, it determines the optimal level of risk within its portfolio. Risk-taking incentives are linked to the cost of funding. If the source of funding is mainly insured deposits, there is a moral hazard, resulting in excessive risk-taking. Alterna-

[1] In the United States, the Office of the Comptroller of Currency (OCC) is responsible for monitoring nationally chartered banks, while each branch of the Federal Reserve System is responsible for state-chartered member banks that have access to the discount window. The Federal Deposit Insurance Corporation (FDIC) is responsible for state-chartered banks that have opted out of the Federal Reserve System. Deposit insurance is the responsibility of the central bank in France and Italy; Japan keeps these institutions separate. The Japanese Minister of Finance, however, has wielded considerable control in past bank resolutions. Australia maintains a separation between its central bank and the Australian Prudential Regulation Authority (APRA).

[2] Garcia (1999) discusses policy issues surrounding coordination between supervisors, central banks, and deposit insurance agencies.

tively, if the bank's liabilities are mainly uninsured, then its cost of funding is sensitive to its choice of risk. Uninsured depositors demand compensation for risk incurred, thus mitigating the moral hazard problem.

This paper also considers how the regulatory regime affects the financial environment. Supervision is modelled as a precommitment to a minimum capital adequacy and prompt corrective-action policy. If the bank fails to meet the minimum capital standard (due to excessive risk-taking), it faces certain closure.[3] Upon closure, a choice is made between liquidation and merger. Due to different objectives, the meta-regulator is more apt to merge than the deposit insurer.[4] Although the meta-regulator uses ex post optimal resolution (EPOR), its choices create ex ante inefficiencies. Uninsured depositors are effectively "bailed out" when there is a merger and (therefore) do not demand a premium against merger outcomes. As a result, a bank is more prone to excessive risk-taking under a "meta-regulatory regime." A meta-regulator can minimize this incentive by raising capital standards; however, this increases disintermediation costs.

In contrast, the deposit insurer makes an ex post welfare-inefficient decision based on minimizing its cost of payout. This slants its decision towards liquidation. Since uninsured depositors suffer loss under liquidation, they demand a higher risk premium when this is more likely. This "market discipline," combined with least costly resolution (LCR), eliminates risk-taking. Within this environment, capital requirements are at best redundant.

Section 2 describes the general model and presents alternative closure regimes. Section 3 describes an unregulated benchmark model without deposit insurance and uses it as a basis for comparison to the other regimes. Section 4 describes a regime with two separate decision makers. The meta-regulator regime is compared with the separate regulatory regime in section 5. This comparison is conducted by a welfare analysis to determine conditions under which a separation of powers makes good policy sense. Section 6 offers some conclusions.

2. General Model

2.1 Agents

The model contains a bank, insured depositors, uninsured depositors, a supervisor, and a deposit insurer. These last two agents are either modelled as separate decision entities or combined as a "meta-regulator." All agents are risk-neutral. Randomness in the model, which determines bank type, is represented by an exogenous probability distribution, which is called "Nature."

[3]Unlike the work by Mailath and Mester (1994), this paper abstracts from issues of discretion in the closure decision by assuming that the pre-announced closure threshold is fully committable.

[4]Enoch, Garcia, and Sundararajan (2001) provide an interesting discussion about the motivations behind recapitalizing banks versus a depositor payout (liquidation).

2.2 Timing

There are three time periods: $t = 0, 1, 2$.

At $t = 0$, the regulatory authority announces a fully committable closure rule. This rule consists of a required capital ratio (ω) and the regulatory policy regime (LCR or EPOR). Next, Nature determines the type of bank. The bank makes its investment decisions. Deposit markets clear, and offered rates of return are determined.

At $t = 1$, depositors and regulators receive a signal of the period-two value of assets in the bank's loan portfolio. The signal is observable but unverifiable to third parties. The supervisor chooses whether to close the bank. If it is closed, the closure resolution policy is implemented. If the bank is liquidated, insured depositors immediately receive their claims, in full, while claims of uninsured depositors are *pari passu* to those of the deposit insurer. The recovery technology is imperfect and thus each dollar of liquidated funds costs $1 - \lambda$.

At $t = 2$, if the bank is still open or was merged, loans mature and depositors are repaid.[5]

2.3 Market participants: banks and depositors

The bank invests $1 + \omega$ dollars in a loan portfolio at time period $t = 0$, where $\$\omega$ is capital; the remainder comes from deposits. The (exogenous) ratio of insured depositors is $\phi \in [0, 1]$; these deposits are protected from default by a deposit insurance corporation. No-arbitrage arguments imply that insured deposits have a risk-free return normalized to zero.

In contrast, uninsured depositors have uncertain rates of return. The gross interest rate demanded on these deposits is denoted $R \equiv (1 + r^u)$. In general, $R > 1$, since it includes a risk premium. Uninsured depositors may instead lend funds at the risk-free rate outside the bank.

The bank determines the optimal level of risk. The value of a bank's loan portfolio is a random variable, $\tilde{A}$, which is uniformly distributed on an interval $[\mu - v, \mu + v]$, $v \leq \mu$.[6] The purpose of this loan portfolio technology is to account for the gambling incentives of the bank. Thus, v is the choice variable for the bank; each portfolio has expected value μ.[7]

The liabilities of the bank at maturity are $A_0 = \phi + (1 - \phi)R$. If realized A is less than A_0, the bank is insolvent. In addition, if there is a positive capital requirement, the bank is shut down at $t = 1$, if $A < A_c$ (where $A_c \equiv A_0/(1 - \omega)$).[8] Owners lose their

[5] This condition creates a distinction between merger and liquidation from the uninsured depositor's perspective. There is no loss-sharing arrangement, in the event of recapitalization, among non-guaranteed creditors.

[6] This parameterization ensures that a mean-preserving spread exists between the riskless and risky choice for the bank.

[7] The bank's return function over v is non-concave on the interval $[0, \mu]$ and its decision is reducible to a choice between $v \in \{0, \mu\}$.

[8] A bank is closed if its net worth at A is less than ωA; or, $A - A_0 \leq \omega A$, where A_C is defined by

capital if the bank is closed, but they are not liable to creditors.[9]

The expected return to a type μ bank if it chooses risk v is:

$$\rho(v) = \int_{A_c}^{\mu+v} (A - A_0)\frac{1}{2v}dA, \tag{1}$$

provided $A_c > \mu - v$. If the bank chooses a level of risk $v < \mu - A_c$, there is no chance of closure and the bank's expected return simplifies to $\rho = \mu - 1$.[10] Finally, since the bank is required by the regulatory authorities to maintain ω in capital, this defines a participation condition for the optimal choice of v^*:

$$\rho(v^*) - \omega > 0. \tag{2}$$

If condition (2) cannot be achieved, then the bank exits and is assumed to transfer all its funds to an alternative risk-free market.

2.4 Nature

After the regulatory authorities announce the policy regime, Nature determines the expected value of the representative bank's loan portfolio, μ. Assume that μ is uniformly distributed on the interval $[\underline{\mu}, \overline{\mu}]$. This feature captures the self-selection aspect of closure policy. Since the policy must be developed ex ante and cannot be revoked, it will affect both the disintermediation decision and the risk-taking incentives of operating banks.[11]

This enables the model to capture another potential source of market failure, since, if $\underline{\mu} < 1$, there are some socially suboptimal projects on the interval $[\underline{\mu}, 1]$. If the regime is lenient (with low capital requirements or high levels of insured deposits), these portfolios remain attractive to a bank provided there is positive probability of solvency. The bank is willing to take a maximal level of risk, since the expected losses in the bad states (or capital-at-risk) are sufficiently small. This *gambling-for-resurrection* behaviour is inefficient, since the socially optimal choice for a bank of type $\mu < 1$ is to disintermediate.

2.5 Regulators

Choice of ex post policy

When $\omega > 0$, the supervisor shuts down banks with low but otherwise positive net worth. The resolution process is a choice by authorities between liquidation and merger with a

the value of A when the bank has zero net worth.

[9]Market discipline affects the bank's expected return in two ways. First, as R increases, the bank owes more funds in the event it is solvent. Second, an increase in the uninsured deposit rate increases the region of closure $[0, A_c]$ and thus the probability of closure.

[10]Equilibrium in the uninsured deposit market ensures that $R \to 1$ as the probability of failure approaches zero.

[11]*Disintermediation* occurs when banks exit due to an inability to attain a sufficient spread between deposit and loan rates of return. This inability to intermediate may be the result of high capital requirements.

healthy bank. If the decision regarding the closure method is delegated to the deposit insurer, they will implement the LCR procedure. In contrast, the meta-regulator chooses to implement the welfare optimal choice between liquidation and merger. One factor that will distinguish the behaviour of the meta-regulator versus the deposit insurer is the cost of using public funds to make payouts. It is assumed that every dollar utilized costs the meta-regulator $1+\theta$ dollars ($\theta \in \mathbf{R}$). There is no reason to assume that θ should be positive. It could be negative, since, in this model, the deposit insurer that faces a deficit would ultimately fund itself at market interest rates, while the meta-regulator could borrow at the government rate. Regardless, the analysis when $\theta < 0$ is no different than when $\theta = 0$.[12]

Liquidation versus merger

In the event of liquidation, the deposit insurer refunds all insured deposits and becomes a claimant on the bank's assets. The loan portfolio is sold at a value λA. Uninsured depositors receive

$$B^{a}(A) = \left[\frac{R(1-\phi)}{R(1-\phi)+\phi}\right]\lambda A = \left[\frac{R(1-\phi)}{A_0}\right]\lambda A. \tag{3}$$

The term in parentheses represents the fraction of funds owed to uninsured depositors. The deposit insurer receives the remainder, $B^{DI}(A) = \phi\lambda A/A_0$.

In the event of a merger, the bank is injected with sufficient capital to ensure that it is attractive enough to be assimilated by a healthy bank. Uninsured depositors are assumed to not suffer any losses under the merger.[13] Therefore, the greater the belief of a merger, the smaller the risk premium demanded by uninsured depositors. This lack of tension will enhance risk-shifting, since all deposit funds are cheaper and less sensitive to changes in the risk profile of the loan portfolio.

Least cost resolution

If the bank is liquidated, the cost to the deposit insurer will be $C_L(A) = \phi - B^{DI}(A)$. In the event that the bank is merged, a level of recapitalization would be required to ensure that its net worth prior to the merger equals ωA.[14] The cost of a merger is therefore the amount of bailout funds required to get a bank back to health:

$$C_M(A) = \phi + (1-\phi)R - A + \omega A. \tag{4}$$

[12]If $\theta = 0$, it will be shown that the meta-regulator always merges, since the merger does not impose a liquidation cost on society. If θ is less than zero, then using public funds is even cheaper and thus it will still always merge. Only when θ is positive does the meta-regulator place a sufficiently high cost on using funds (either privately or publicly raised) to consider liquidation as an option.

[13]As a first-order approximation, this is true. See Hoggarth, Reidhill, and Sinclair (2004) for a description of alternative loss arrangements.

[14]A healthy bank will not assume the balance sheet of a failed bank with zero net worth, since neither regulators nor the market will accept an ex post merged entity that is undercapitalized.

This cost includes recapitalization funds (ωA) necessary to attract another healthy bank to merge. Notice that the ex ante risk premium demanded by the uninsured depositors increases the cost of closure under merger.

The LCR criterion is a critical value of A_M such that

$$C_M(A_M) = C_L(A_M),$$

or

$$A_M = \frac{A_0(1-\phi)R}{(1-\lambda-\omega)\phi + (1-\omega)(1-\phi)R}. \tag{5}$$

Therefore, for $A \in [A_M, A_C]$, the bank is merged, and for $A < A_M$, the bank is liquidated. Under certain cases, $A_M > A_C$, which implies that a closed bank is always liquidated. The merger region is affected by parameters directly, but also indirectly through changes in financing costs, R.[15]

Ex post optimal resolution

In contrast, the meta-regulator makes an ex post efficient resolution decision. Assume that welfare can be measured as the sum of nominal surpluses of all economic units. There are three cases to consider:

(i) If $A > A_C$, the bank is not closed and welfare is measured by the final wealth positions of the three private entities:

$$W_o(A) = \phi + (1-\phi)R + [A - \phi - (1-\phi)R] = A. \tag{6}$$

(ii) If $A < A_C$, then the bank is closed and either merged or liquidated. If merged, the welfare is:

$$W_M(A) = \phi + (1-\phi)R + [(1+\theta)((1-\omega)A - \phi - (1-\phi)R)] + \omega A. \tag{7}$$

Equation (7) has four components. The first two are the amounts that accrue to depositors of the bank. The third component is the cost of recapitalization to government. The parameter θ captures the per-dollar-distortion associated with using public funds to resolve a bank. The fourth component is the net benefit that accrues to the banking sector from injecting $(1-\omega)A - \phi - (1-\phi)R$ worth of funds into a bank with assets worth A and liabilities of A_0.

(iii) If the bank is liquidated, the welfare is:

$$W_L(A) = \phi + \left[\frac{(1-\phi)R}{\phi + (1-\phi)R}\lambda A\right] + (1+\theta)\left[\frac{\phi\lambda A}{(1-\phi)R + \phi} - \phi\right]. \tag{8}$$

[15] Section 4.1 describes the equilibrium R when a failed bank can either be merged or liquidated. Exogenous parameters have an indirect effect on the merger region through R.

Following the logic of LCR, there exists an A^* such that

$$W_M(A^*) = W_L(A^*),$$

or

$$A^* = \frac{\theta(1-\phi)R}{1+\theta(1-\omega)-\lambda-\frac{\lambda\theta\phi}{(1-\phi)R+\phi}}. \tag{9}$$

For $A < A^*$, the socially optimal policy is to liquidate.

One special case merits further comment. When $\theta = 0$, there is never any possibility of liquidation (since $A^*(\theta = 0) = 0$), and welfare is A regardless of whether the bank succeeds or fails.[16]

Figure 1 illustrates the choices graphically. Diagram (a) depicts the cost curves of the deposit insurer and identifies the merger region $[A_M, A_C]$. Diagram (b) shows the welfare curves for the meta-regulator, defining the merger interval $[A^*, A_C]$. A_0, the insolvency point, is positioned to the left of A_C; however, there is no constraint on its position relative to either A_M or A^*. These points can be below A_0, which implies that a merger is possible even when the bank is insolvent. Likewise, these points can be above A_C, which implies that mergers are not possible whenever the bank is closed.[17]

Optimal ex ante policies

At $t = 0$, after the choice of regulatory regime (EPOR or LCR) is made, the supervisor chooses ω that maximizes expected welfare by taking expectations over the distribution of bank types $\mu \in [\underline{\mu}, \overline{\mu}]$.

To measure expected welfare, it is necessary to determine which of three mutually exclusive sets $\{E, C, X\}$ each bank type belongs to. If $\mu \in E$, then the bank chooses to exit and lend out $1+\omega$ at the risk-free rate. If $\mu \in C$, then the bank chooses the riskless loan portfolio with a return of $\mu - 1$.[18] Individual rationality requires $\mu - 1 \geq \omega$, for $\mu \in C$. Finally, if $\mu \in X$, then the bank chooses to take on risk $v > 0$ and the return is uncertain. Welfare is trivial to measure in the first two cases. If $\mu \in X$, then there are three possible outcomes: (i) success (O), (ii) failure with merger (M), and (iii) failure with liquidation (L).

Accordingly, ex ante expected welfare is defined as

$$E_\mu[W(\omega)] = \int_{\mu\in E} \frac{1+\omega}{\overline{\mu}-\underline{\mu}} dU + \int_{\mu \in C} \frac{\mu}{\overline{\mu}-\underline{\mu}} dU$$

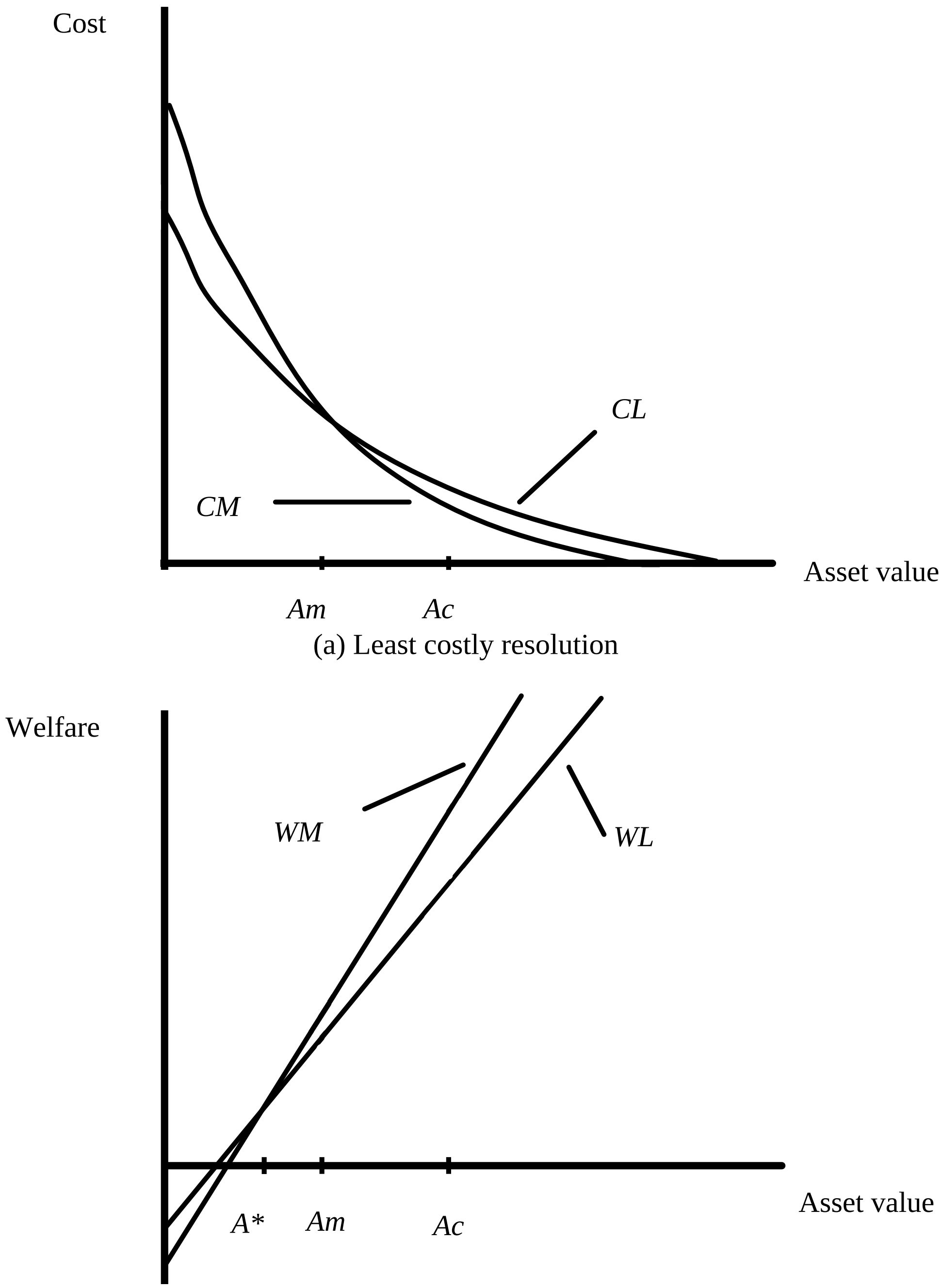
$$+\int_{\mu\in X}\left[\int_{A\in L} W_L(A)\frac{1}{2v}dA + \int_{A\in M} W_M(A)\frac{1}{2v}dA + \int_{A>A_c} W_O(A)\frac{1}{2v}dA\right]\frac{1}{\overline{\mu}-\underline{\mu}}dU. \tag{10}$$

[16] With no frictions created under merger $W_M(A) = A > W_L(A) = \lambda A$, provided there is a recovery cost to liquidation, $\lambda < 1$.

[17] A plausible scenario is $A^* < A_C < A_M$. In this scenario a deposit insurer would always liquidate a closed bank, whereas a meta-regulator would allow a merger of a closed bank provided it is sufficiently capitalized.

[18] If $v = 0$, then no-arbitrage in the uninsured deposit market ensures that $R = 1$.

Figure 1: Cost Curves of Deposit Insurer, Welfare Curves of Meta-Regulator, and Critical Thresholds under LCR and EPOR. CM and CL represent the cost of merger and liquidation for different bank-asset values. WM and WL describe welfare associated with merger and liquidation for different A.



(a) Least costly resolution

(b) Ex post optimal resolution

This measure needs to be normalized in order to compare it with an unregulated benchmark ($\omega = 0, \phi = 0$). Banking in an unregulated environment uses up \$1 of resources, whereas a regulated bank uses \$$(1+\omega)$. Instead of making comparisons in dollars, the ex ante expected return on welfare is used:

$$E[R_\omega] = \frac{E_\mu[W(\omega)]}{1+\omega}. \tag{11}$$

3. Unregulated Benchmark

This section provides a basis for comparison between the two regulatory structures. An unregulated bank is neither supervised nor protected by deposit insurance. Instead, the oversight role is delegated to uninsured depositors.

3.1 Uninsured deposit rate equilibrium

Lacking regulatory capital requirements, the bank borrows uninsured funds equal to 1 in period 0 and then pays back R in period 2 (provided $A \geq R$). If the bank cannot pay R, then it is liquidated for λA. Hence, R is determined by the following no-arbitrage condition:

$$\int_{\mu-v}^{R} \frac{\lambda A}{2v} dA + \int_{R}^{\mu+v} \frac{R}{2v} dA = 1, \tag{12}$$

provided that $R > \mu - v$; otherwise, $R = 1$.

This condition says that R equates an uninsured depositor's expected return from lending to a bank (of type μ taking risk v) with the risk-free alternative market return. Provided there is default risk ($\mu - v < R$), the following solutions exist for the quadratic equation (12):

$$R = \frac{\mu + v \pm \sqrt{(\mu+v)^2 - (2-\lambda)(\lambda(\mu-v)^2 + 4v)}}{2-\lambda}. \tag{13}$$

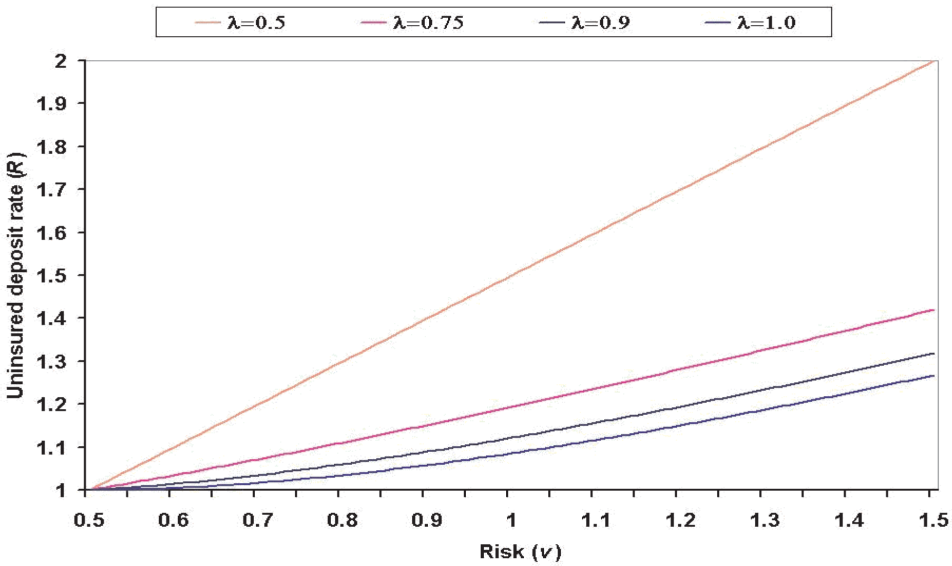
Thus, the no-arbitrage condition describes a positive relation for the bank between R and v.[19] The more risk the bank takes, the higher is the risk premium demanded. Likewise, market discipline ensures that inefficient banks ($\mu < 1$) cannot obtain deposits. Consider a "best-case" scenario where liquidation is frictionless ($\lambda = 1$). Equation (13) becomes $R(\lambda = 1) = \mu + v - 2\sqrt{v(\mu - 1)}$. For the deposit rate to exist, $\mu > 1$ is necessary. If the liquidation technology is imperfect, the risk premium increases further.

These results suggest that market discipline is effective and responsive to changes in both endogenous and exogenous variables. Figure 2 describes the risk premium demanded by depositors for different recovery rates (λ) when the bank is of type $\mu = 1.5$.

The risk premium is increasing in v and this effect is more pronounced for a lower recovery ratio (or a higher cost of liquidation). The first assertion is summarized in Lemma 1.

[19] The positive root is dropped, since $R^+ \geq R^- \geq 1$ whenever $\mu > 1$ and $v \geq \mu - 1$.

Figure 2: Uninsured Deposit Rate $R(v)$ Schedules for Various Recovery Ratios, λ



Lemma 1 *The uninsured deposit rate (13) is non-decreasing in* v *for* $v \in [\mu - R, \mu]$.

Proof. See the appendix for proofs of all lemmata and propositions.

Next, consider how the bank responds to this deposit rate schedule.

3.2 The bank's decision

The bank maximizes its expected return, choosing v, subject to the rationality condition (2). Since $\omega = 0$, the bank lends provided $\rho(v^*) > 0$, and exits otherwise.

If the bank is able to raise loanable funds, its expected return is:

$$\rho(v) = \int_{R(v)}^{\mu+v} (A - R(v)) \frac{1}{2v} dA = \frac{(\mu - R(v))^2}{4v} + \frac{\mu}{2} + \frac{v}{4} - \frac{R(v)}{2}, \tag{14}$$

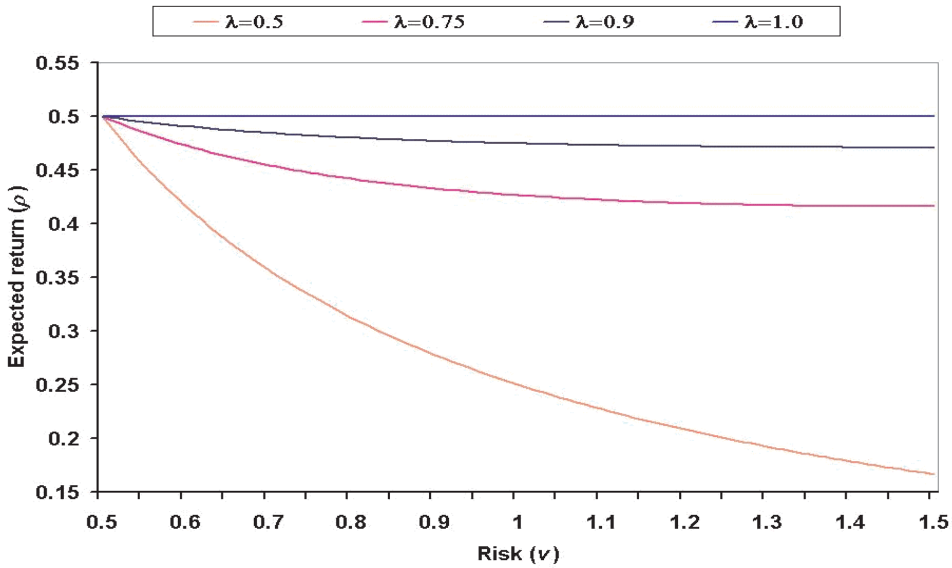
provided $v \in (\mu - R(v), \mu]$.[20] Otherwise, its debt and returns are risk-free ($R(0) = 1$ and $\rho(0) = \mu - 1$).[21]

Figure 3 summarizes the expected return for the bank as a function of its risk, for different λ. This figure highlights the lack of incentive for risk-shifting. Setting risk to

[20] In an unregulated market, with no deposit insurance, the parameters $\phi = 0$ and $\omega = 0$ imply $A_0 = A_c = R(v)$.

[21] If the bank chooses $v < [0, \mu - R(v)]$, then there is no chance of failure. Since the bank's expected return is $\mu - 1$ on this interval, assume it chooses $v = 0$.

Figure 3: Expected Return $\rho(v)$: $\mu = 1.5$.



zero ensures a return $\rho(0) = \mu - 1$, while increasing v past $\mu - R(v)$ lowers expected returns. Only when there is no liquidation cost ($\lambda = 1$) is the bank indifferent between risk-shifting and zero risk. As before, the divergence of $\rho(v)$ from $\rho(0)$ is larger for lower λ. This conclusion (that the bank will not risk-shift in the absence of deposit insurance) is consistent with Kareken and Wallace (1978). A bank that faces pressure from uninsured creditors is inclined to minimize the number of states in which negative net worth can arise. Kareken and Wallace find that this goal is best achieved by reducing risk-taking to zero.

3.3 Expected welfare

Without a regulator, expected welfare can be measured by expected private wealth. In the solvent state, uninsured depositors and the bank receive R and $A - R$, respectively, resulting in welfare $W_o = A$. In the insolvent state, uninsured depositors receive λA and the bank receives zero due to limited liability. Hence, welfare is reduced to $W_L = \lambda A$. Given the population, $\mu \sim [\underline{\mu}, \overline{\mu}]$, of bank types, expected welfare is:

$$E[W(\mu)] = \int_{\mu\in E} \frac{1}{\overline{\mu} - \underline{\mu}} dU + \int_{\mu\in C} \frac{\mu}{\overline{\mu} - \underline{\mu}} dU + \int_{\mu\in X} \left[\int_{\mu-v}^{R(v)} \frac{\lambda A}{2v} dA + \int_{R(v)}^{\mu+v} \frac{A}{2v} dA \right] \frac{1}{\overline{\mu} - \underline{\mu}} dU.$$

The results of this section lead to the following proposition:

Proposition 1 *In an unregulated banking economy equilibrium, whenever $\lambda < 1$: (i) there will be no risk-shifting by banks, (ii) there will be no gambling-for-resurrection opportunities, and (iii) the equilibrium maximizes expected welfare.*

In the case described in Proposition 1, the market provides sufficient discipline for banks, and any further intervention (supervision or deposit insurance) is redundant at best. Capital regulation becomes necessary only as soon as one introduces deposit insurance, since the extension of the safety net erodes market discipline. Why is there deposit insurance? Motivation for its adoption comes from separate policy objectives, including the protection of small depositors and the promotion of financial stability. Whether this rationale is correct is beyond the scope of this paper's analysis.[22]

4. Resolution/Closure with Separate Regulators

In a two-stage regulatory approach, the supervisor determines ex ante conditions under which a bank will be closed and then delegates to the deposit insurer the decision of how to resolve the closure using an LCR criterion.

Consider a state where the bank is closed due to insufficient capital. Algebraic manipulation of the inequality $A_M < A_C$ shows that a necessary condition for mergers is:

$$\omega < 1 - \lambda. \tag{15}$$

The per-dollar cost to the insurer of recapitalizing must be less than the per-dollar cost of liquidating the bank. This only ensures that mergers are possible and does not guarantee that mergers will occur upon closure. If condition (15) is satisfied, a merger will be chosen if the asset realization is in the interval $A \in [A_M, A_C]$. If not (namely, when $A < A_M$), then the bank will be liquidated.

Under LCR, the deposit insurer has an incentive to avoid bailing out all the bank's creditors through merger. Even if it is cheaper to merge, the scope of the deposit insurer's liability widens when funds owed by the bank are largely uninsured. If the deposit insurer chooses to liquidate, they need only reimburse insured deposits. For banks with poor loan performance (due to excessive risk), there is a greater likelihood of liquidation, since a merger becomes prohibitively expensive if the creditors are mainly uninsured.

Consequently, risk-shifting incentives are hindered when uninsured creditors believe the bank will be liquidated upon failure, since they demand a larger risk premium, *ceteris paribus*. The logical by-product of increased market discipline is less moral hazard.

4.1 Uninsured deposit rate equilibrium

Following the previous section's methodology, the deposit rate is determined by no-arbitrage arguments. However, there are three cases to consider. In case (i) mergers are possible, $1 - \lambda > \omega$ (implying $A_M < A_C$), and the bank chooses a risky portfolio,

[22] Bryant (1980) and Diamond and Dybvig (1983) provide theoretical motivations for deposit insurance as a mechanism for eliminating depositor-induced bank runs. See also Garcia (1999) for a comprehensive discussion of the motivations behind deposit insurance.

(implying $v > \mu - A_M$). Therefore, the equilibrium uninsured deposit rate, $R_M(v)$, is a solution to:

$$\int_{\mu-v}^{A_M(v)} \left[\frac{R_M(v)\lambda A}{\phi + (1-\phi)R_M(v)}\right] \frac{1}{2v} dA + \int_{A_M(v)}^{\mu+v} \frac{R_M(v)}{2v} dA = 1. \tag{16}$$

In case (ii), no mergers are possible, since $1 - \lambda < \omega$, but the bank is risk-shifting. The boundaries of integration are affected by the closure point, A_C, instead of A_M. $R_C(v)$ is a solution to:

$$\int_{\mu-v}^{A_C(v)} \left[\frac{R_C(v)\lambda A}{\phi + (1-\phi)R_C(v)}\right] \frac{1}{2v} dA + \int_{A_C(v)}^{\mu+v} \frac{R_C(v)}{2v} dA = 1. \tag{17}$$

Equation (16) is a third-order polynomial; however, in the range $[1, \mu + v]$, the solution $R(v)$ is unique and provides intuitive comparative statics. Likewise, equation (17) defines a second-order polynomial similar to equation (12). Finally, in case (iii) the bank has chosen zero risk and $R = 1$ is the equilibrium deposit rate solution.

The bank's decision

The introduction of a minimum capital requirement ($\omega > 0$) and deposit insurance creates distortions in the behaviour and incentives of the bank and depositors. Consider the expected return to the bank when it will be shut down if $A < A_C$. If there is risk of failure, the expected return is:

$$\rho(v) = \int_{A_c(v)}^{\mu+v} [A - A_0(v)] \frac{1}{2v} dA. \tag{18}$$

$$= \frac{1}{4v}\left[\mu^2 - \frac{A_0(v)^2}{(1-\omega)^2} - 2A_0(v)\mu + \frac{2A_0(v)^2}{1-\omega}\right] + \frac{\mu - A_0(v)}{2} + \frac{v}{4}.$$

The bank's problem at $t = 0$ is to choose $v^* \in [0, \mu]$ that maximizes its expected return, $\rho(v)$, given the closure rule defined by A_c, and also the uninsured deposit rate schedule $R_i(v)$ $i = C, M$.

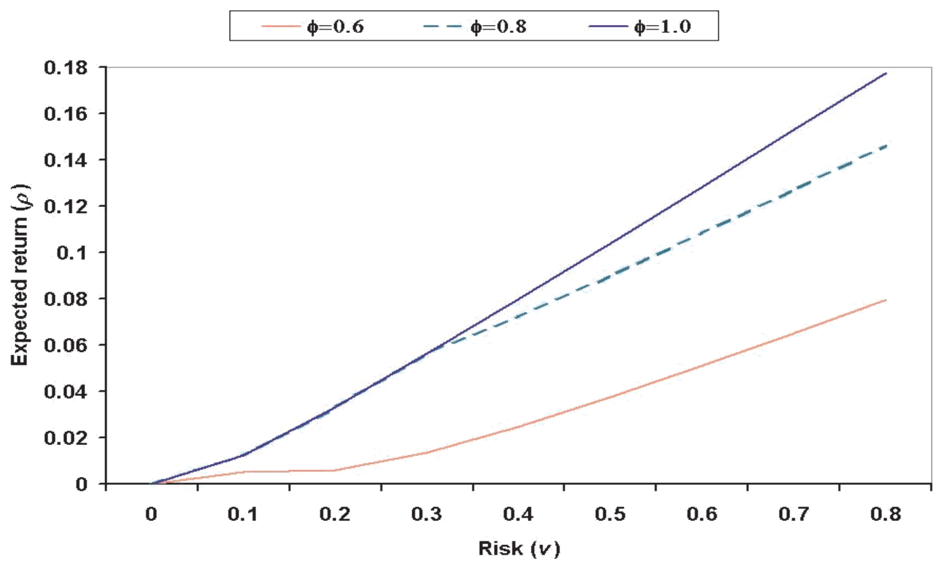
For tractability, *assume that the bank has a binomial choice set,* $v \in \{0, \mu\}$. Instead of considering intermediate levels of risk, the analysis examines only zero and maximal risk as options. Lemma 2 (in the appendix) provides reasonable conditions under which this expected return function would be non-concave on the interval $[R, 2\mu]$, ensuring the optimal corner solution.[23]

[23] In particular, $\rho(v)$ is shown to be non-concave for an unregulated banking economy ($\phi = 0$ and $A_0 = R$) and a hypothetical always-merge regulatory regime (implying $R(v) = 1$, $\forall v$ and $A_C = 1$). The regulatory structure in this section lies in between these two extreme cases.

Risk incentives of banks

Gambling-for-resurrection occurs when a bank of type $\mu < 1$ chooses maximal risk. This may be optimal if it has no choice but to take maximal risk or disintermediate. This is a behavioural consequence of introducing the safety net, since gambling did not occur in the unregulated benchmark economy. Figure 4 shows the expected return function for a bank (of type $\mu = 0.9$) that faces zero capital requirements. For the three ratios of insured deposits shown in the figure, maximal risk is optimal and $\rho(\mu)$ increases in ϕ. This reflects lower funding costs as insured deposits replace uninsured deposits. Likewise, there is a higher likelihood of merger in the event of failure, which reduces the risk premium demanded by the remaining uninsured depositors. The implication is lower ex ante expected welfare than if there were no insured deposits.

Figure 4: Expected Return $\rho(v)$ for Various Ratios of Insured Deposits ϕ: $\mu = 0.9$, $\lambda = 0.75$, $\omega = 0$



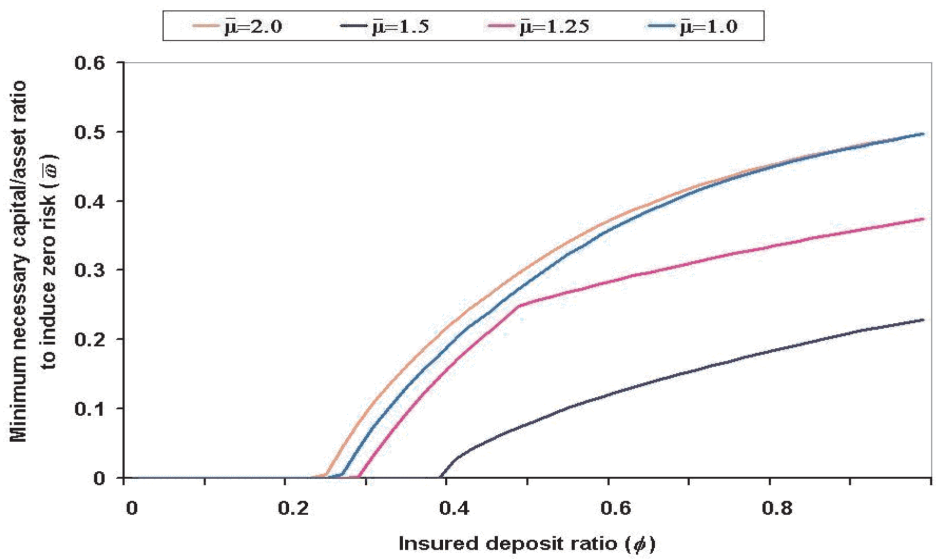
The above analysis suggests a need for a second instrument to realign private incentives for risk with social objectives. Introducing capital requirements is one solution. Increasing ω will increase the cost of failure, since the bank must set aside more capital against the same expected revenue stream. Likewise, increasing ω increases the likelihood that a failed bank will be liquidated, leading to a higher risk premium. The trade-off is disintermediation. As ω increases, a subset of banks exit, due to the high costs of capital. Eventually, there are no benefits from increasing ω, since all banks are choosing zero risk. Proposition 2 describes general boundaries.

Proposition 2 *There exists a minimum level of capital $\overline{\omega}(\lambda, \phi) \in [0, \frac{1}{2}]$ such that, for any given $\lambda > 0.5$ and $\phi \in [0, 1]$, there will be zero risk-shifting by banks for $\omega \geq \overline{\omega}(\lambda, \phi)$.*

Suppose $\phi \to 1$, which implies that $A_0 \to 1$, since there is no risk to depositors (and consequently no market discipline). In the limit, there is no risk premium; yet, if the regulator sets $\omega \geq \frac{1}{2}$, no bank type will take on risk, implying a threshold for capital requirements beyond which there is no incentive for risk. Instead, if market discipline is present, risk-shifting by a bank will raise A_0 above 1, further increasing the bank's incentive to set $v = 0$. Consequently, there is less need to set a high capital requirement than when market discipline is absent.

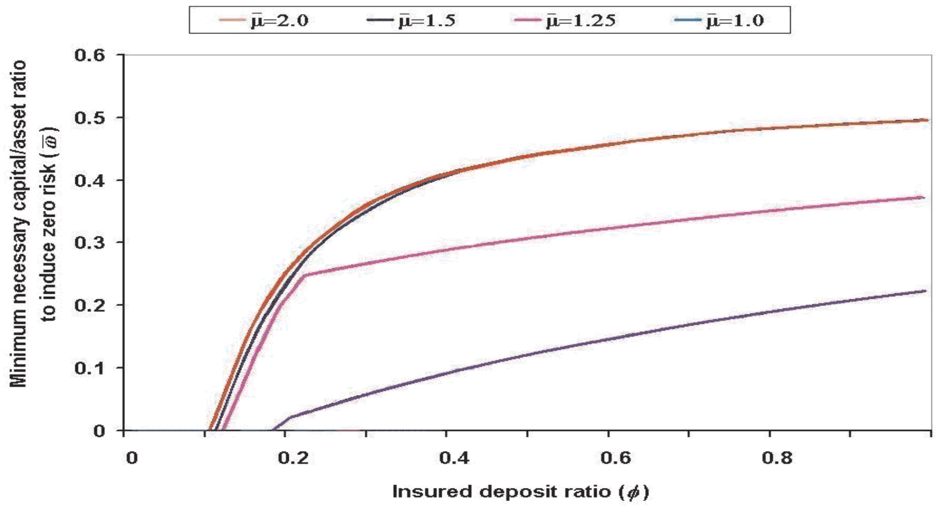
Instead, consider the effect of λ varying. Based on condition (15), if ω is set in the interval $[1 - \lambda, 0.5]$, then mergers are not possible. Increased likelihood of liquidation enhances market discipline, raising A_0 above 1, and the arguments of the previous paragraph follow. Proposition 2 argues that either $\lambda < 1$ or $\phi < 1$ lowers the minimum necessary capital requirement to induce zero risk. Figures 5 and 6 show the effects of different uninsured deposit ratios, (ϕ), on $\overline{\omega}$.

Figure 5: Minimum Capital-Asset Ratio Necessary to Eliminate Risk-Shifting under LCR, $\overline{\omega}(\mu, \phi)$, given μ and ϕ $\overline{\omega}(\mu, \phi)$: $\lambda = 0.7$



Both figures show, for a given level of λ, the minimum level of $\overline{\omega}$ required to ensure zero risk-taking for a bank of the type ranging from $\mu = 1.0$ up to $\mu = 2.25$. The figures highlight how important uninsured depositors are to determining the strength of prudential supervision. If there is a sufficiently large enough proportion of uninsured depositors ($\phi \to 0$), capital requirements are unnecessary. Likewise, if the bank has lower loan quality, μ, market discipline is less relevant, since the incentives of the bank are more closely aligned with the social objective of limiting risk-taking. The cost of raising capital is very sensitive to increases in risk, since there is less margin for error. Moving from Figure 5 to Figure 6, the recovery rate is increased. There is an increased

Figure 6: Minimum Capital-Asset Ratio, given μ and ϕ, $\varpi(\mu, \phi)$: $\lambda = 0.9$



dependence on capital requirements, especially at lower levels of insured deposits, *ceteris paribus*. In general, when λ increases, there are offsetting effects. Although higher λ increases the likelihood of liquidation under insolvency, it also lowers the expected loss under liquidation to uninsured creditors, thus lowering the risk premium. As $\lambda \to 1$, liquidation will always be chosen, and the latter effect dominates.

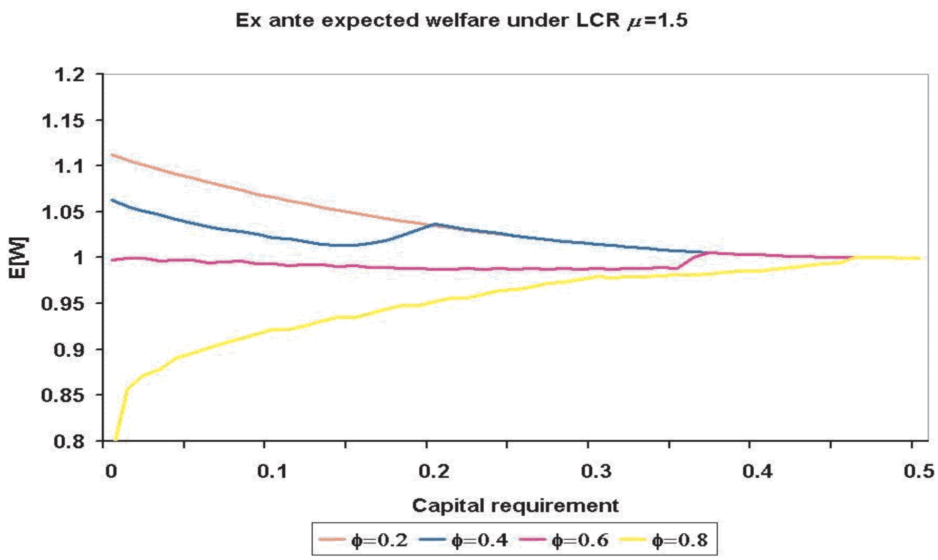
Determining how the financial environment affects capital requirements does not establish a normative position, since it fails to prescribe what is welfare-optimal. This analysis fails to consider distortions caused by higher ω. It does help identify inefficient choices of ω: if ω is chosen above $\varpi(\lambda, \phi)$, there are higher disintermediation costs and no clear benefits beyond $\omega = \varpi(\lambda, \phi)$. The next subsection considers the trade-off between minimizing risk through capital controls versus the efficient allocation of loanable funds.

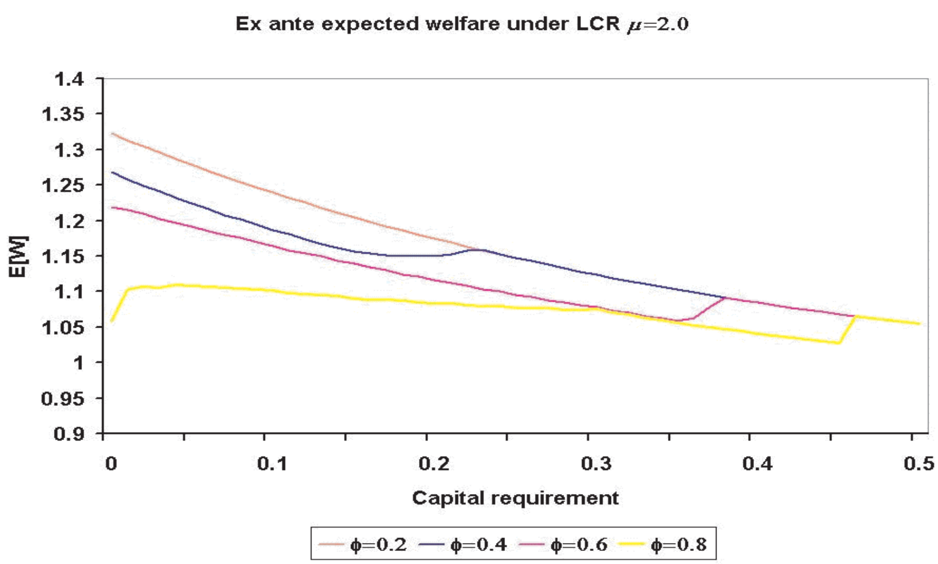
4.2 Expected welfare under LCR

This subsection determines the efficient capital ratio by determining the ex ante expected welfare associated with various requirements ($\omega \in [0, 0.5]$). Assume that the range of possible bank types is uniformly distributed on the interval $\mu \in [0.5, \overline{\mu}]$. The upper bound for μ will be varied ($\overline{\mu} \in \{1.5, 2\}$). The ex ante optimal policy must consider both how the policy affects disintermediation among different types of banks and the resulting risk-taking incentives for those that remain in the market. (The appendix provides a more technical summary of the numerical procedure.)

Figure 7 illustrates how ex ante expected welfare varies with capital requirement

Figure 7: Ex Ante Expected Welfare under LCR: $\theta = 0$, $\lambda = 0.7$





policy choices under LCR (assuming that $\theta = 0$).[24] For small ϕ, uninsured depositors are able to exert sufficient discipline to keep the bank from increasing risk. This leads to a negative relationship between ω and the welfare function. The optimal choice is $\omega^* = 0$ in the presence of effective market discipline, since regulatory capital is redundant and possibly distorting.

Discipline dissipates as the ratio of insured depositors increases. Ultimately, a threshold (denoted as $\underline{\phi}$) is reached, past which the ex ante expected welfare function is increasing in ω.

Varying $\overline{\mu}$ shows how sensitive ω is to the probability of dealing with an inefficient bank (i.e., the $Prob[\mu < 1]$ is non-increasing in $\overline{\mu}$). Increasing $\overline{\mu}$ increases the threshold of $\underline{\phi}$ beyond which capital requirements are necessary. Since $[\underline{\mu}, 1]$ constitutes a smaller proportion of the underlying population as $\overline{\mu}$ increases, gambling is less likely even without capital requirements.

The ex ante expected welfare associated with the optimal capital choice can be compared with the ex ante expected welfare in an equivalently parameterized unregulated market. In the unregulated case, market discipline will force banks of type $\mu \in [\underline{\mu}, 1]$ to exit, resulting in realized welfare of 1. For $\mu > 1$, market discipline ensures that the bank will choose zero risk, leading to a realized welfare of μ. Hence, ex ante expected welfare in the unregulated benchmark is:

$$E_\mu[W^{ur}] = \int_{\underline{\mu}}^{1} \frac{1}{\overline{\mu} - \underline{\mu}} d\mu + \int_{1}^{\overline{\mu}} \mu \frac{1}{\overline{\mu} - \underline{\mu}} d\mu = \frac{\overline{\mu}^2}{2\overline{\mu} - 1}, \quad \text{assuming} \quad \underline{\mu} = \frac{1}{2}. \tag{19}$$

For the two cases considered: $E_\mu[W^{ur}(\overline{\mu} = 1.5)] = 1.125$, and $E_\mu[W^{ur}(\overline{\mu} = 2.0)] = 1.333$.[25] Calculations show that LCR can come very close to achieving the upper-bound benchmark. Closer examination reveals that LCR approaches this upper bound only when there is evidence of market discipline. As soon as market discipline diminishes, LCR diverges and can achieve only a second-best outcome when capital requirements are incorporated. Result 1 summarizes these findings:

Result 1 *In a regulated banking economy with an LCR policy, the optimal policy mix approaches a first-best welfare outcome only in the presence of effective market discipline. If there is not effective market discipline, then the optimal policy mix fails to approach first-best, irrespective of capital regulation.*

Section 5 compares these results with a meta-regulator regime.

[24] Varying this parameter has no effect on the LCR decision. It affects the EPOR decision and also the decision on whether to have a meta-regulator or a separate supervisor and deposit insurer.

[25] These values are slightly above their respective expected values for the loan portfolio of $E[\mu] = (\underline{\mu} + \overline{\mu})/2$, because the realizations of $\mu < 1$ result in a minimum welfare of 1, when the bank is forced to exit.

5. Resolution/Closure with Meta-Regulation

In contrast to LCR, the resolution decision by a meta-regulator is dictated by ex post efficiency (EPOR). What are the differences relative to LCR? The cost-minimizing choice of the deposit insurer is nested within the decision of the meta-regulator, since one of the objectives of the meta-regulator is to take into account the costs of liquidation versus merger along with insured depositors. The meta-regulator, however, takes into account surplus generated by financial intermediation along with uninsured depositors, and also considers the shadow cost of raising public funds when deciding on policy. Equations (7) and (8) describe the welfare associated with merger and liquidation. The threshold, A^*, is where the welfare associated with mergers and liquidation are equal, as defined in equation (9).

How does A^* compare with A_M under LCR? Proposition 3 summarizes the relationship.

Proposition 3 *If $\lambda < 1$ and $\phi < 1$, then $\forall \theta > 0$ (i) $A^* < A_M$ and (ii) A^* is increasing in θ.*

The meta-regulator has a greater predisposition towards merger than the deposit insurer, *ceteris paribus*. Suppose $\theta = 0$; then, one should always expect resolution by merger under EPOR, whereas the range of merger, $[A_M, A_C]$, could be very small, or non-existent under LCR.[26] Section 4 showed that it is increasingly necessary to impose capital requirements as market discipline weakens. This suggests that the meta-regulator will be more reliant on ex ante capital requirements to limit risk-taking, since they cannot rely on market discipline. As θ increases above zero, however, the meta-regulator places a higher cost on recapitalization and A^* increases. This improves market discipline, since uninsured depositors must consider the possibility of liquidation in the ex post environment. Consequently, there is less reliance on capital requirements to limit risk-shifting. Even for large θ, however, Proposition 3 states that the meta-regulator will never adopt a harsher stance on mergers than a deposit insurer under LCR.

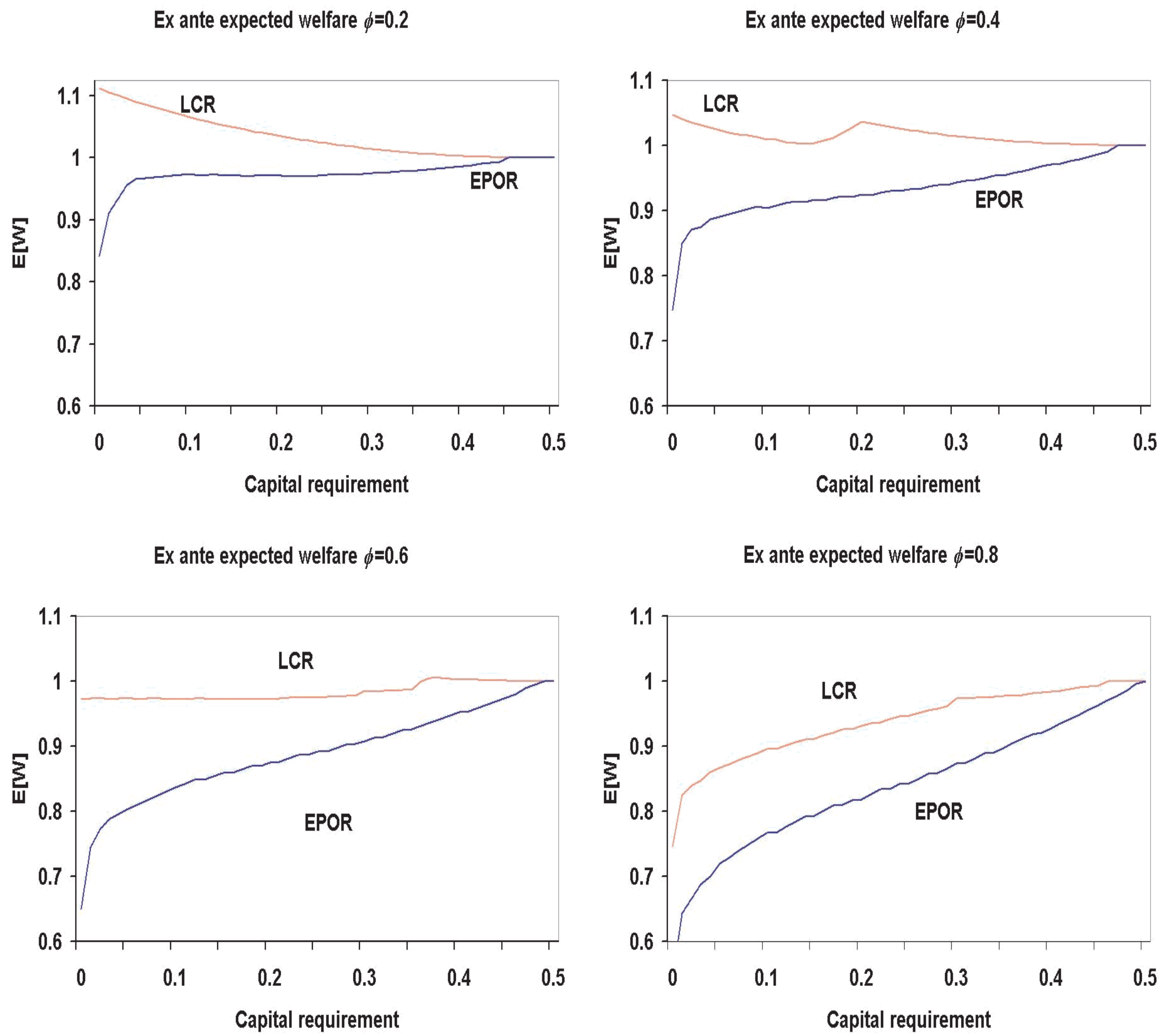
5.1 Ex ante optimal capital requirements and choice of regime

Given a prior understanding that EPOR policy is not as "tough" (ex post) on problem banks, this section compares the ex ante optimal capital requirements under each regulatory regime, for various parameterizations. Figure 8 shows a series of diagrams that compare EPOR with LCR for different insured deposit ratios when there is a low shadow cost, $\theta = 0.1$. The second set, Figure 9, raises the cost to $\theta = 0.5$. The first striking feature (common to all figures) is the weak dominance of LCR over EPOR. This is especially true for low θ. As θ increases, A^* converges towards A_M and mergers become less likely under EPOR; the dominance is less pronounced. The diagrams show that, when $\phi = 0.2$, the welfare outcome improves under EPOR as θ increases, and this is achieved

[26] Evaluating the threshold for a merger under EPOR ($A^*(\theta = 0) = 0$) confirms this.

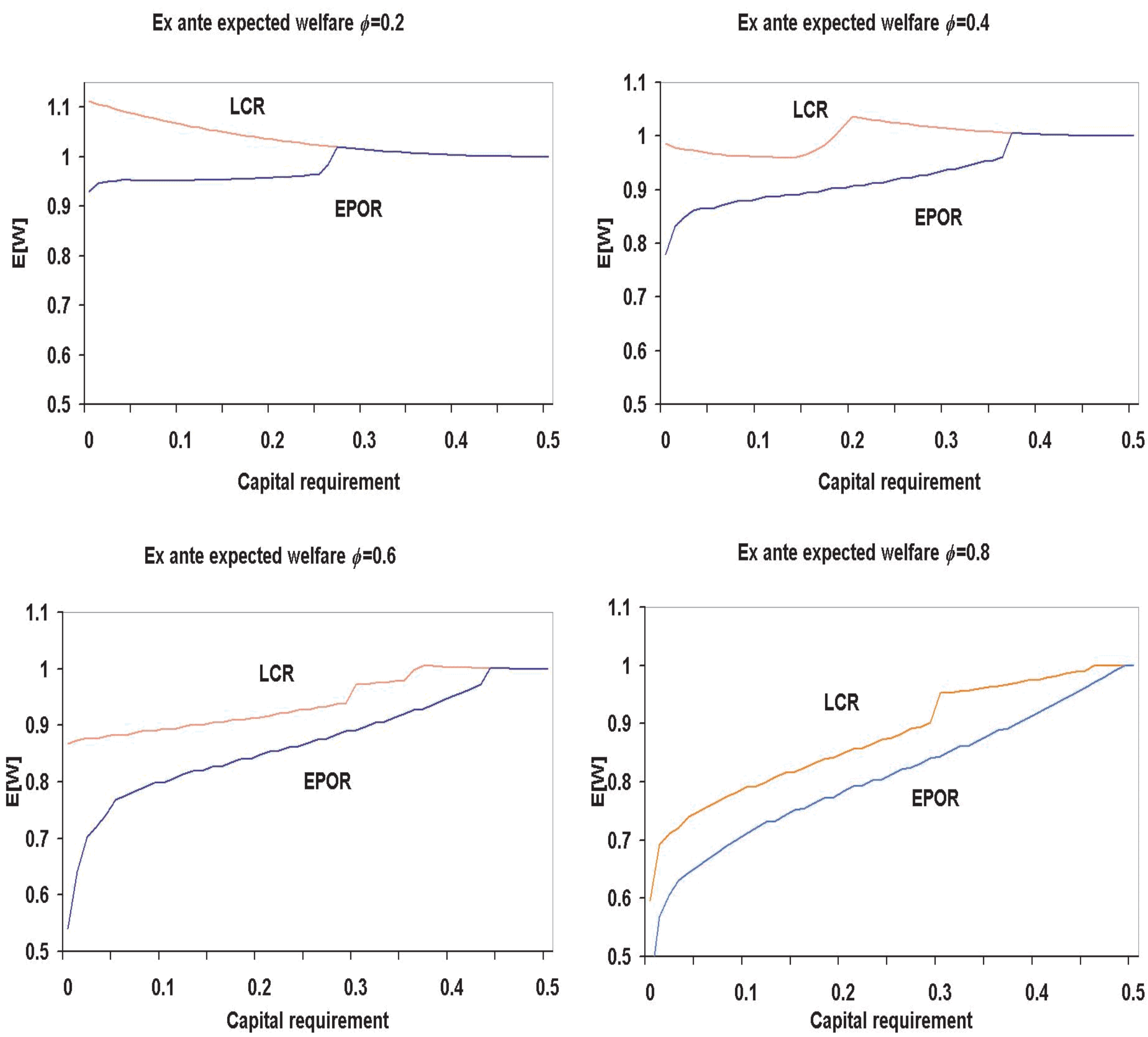
with less reliance on high capital requirements. Threats of liquidation enhance market discipline, but that requires a belief that public funds are costly to raise.

Figure 8: Ex Ante Optimal Capital Requirements: $\theta = 0.1$, $\lambda = 0.7$, $\mu \sim uniform[0.5, 1.5]$



Consider the effect of increasing ϕ, the ratio of insured depositors. Since this increases the likelihood of risk-shifting, *ceteris paribus*, the ex ante optimal capital choice increases. Given that EPOR is more prone to a merger, there is a greater (and earlier) reliance on capital requirements to compensate for the weakened market discipline. Only when insured deposits represent a large proportion of the bank's liabilities does the LCR regime fail to improve upon EPOR. For low levels of insured deposits, EPOR requires a higher capital requirement to achieve the same level of expected welfare as under LCR

Figure 9: Ex Ante Optimal Capital Requirements: $\theta = 0.5$, $\lambda = 0.7$, $\mu \sim uniform[0.5, 1.5]$



(and even then it is not always possible). As ϕ increases, there is very little difference between EPOR and LCR at the ex ante efficient capital ratio. Even LCR requires a high capital requirement to mitigate risk-shifting by banks.

6. Conclusions

This paper has determined conditions under which an independent deposit insurance agency, following an LCR policy, results in a better ex ante performance for the banking sector. This dominance exists only when there are sufficient numbers of uninsured depositors that believe a failed bank will likely be liquidated. When market discipline exists, banks are less likely to incur risk in an LCR environment. Under EPOR, uninsured depositors expect a merger as a likely resolution choice and do not demand a risk premium equivalent to an LCR regime. The result is that banks take more risk, increasing the likelihood of failure ex post. This effect can be mitigated by capital requirements, which, however, introduce a new distortion: disintermediation. Higher capital requirements increase the likelihood that the bank will exit, failing to efficiently reallocate capital towards welfare-improving lending opportunities. Even if the bank stays, more funds are required against the same level of benefits. This is the cost of reducing moral hazard under EPOR.

In contrast, an LCR regime need not impose capital requirements that are as stringent as under EPOR, provided there is a sufficient proportion of uninsured depositors. This places an additional precondition on the dominance of LCR over EPOR. If a bank is funded mainly by insured deposits, the predisposition for risk-taking returns, because there are not sufficient numbers of uninsured depositors to influence the lending decision of the bank. Also, with a larger proportion of insured depositors, the deposit insurer is more likely to merge the bank if it fails. As the ratio of insured deposits increases, the cost to the deposit insurer of recapitalizing the bank increases less (especially for low capital requirements) relative to the cost of liquidation. This increases the range over which the bank will be merged if it fails, thus increasing the likelihood that the remaining uninsured depositors will be repaid. As before, the risk-shifting incentive of the bank can be mitigated by raising capital requirements. The result is that the optimal choice of capital and ex ante expected welfare converge under EPOR and LCR as the ratio of insured deposits increases.

This suggests that market discipline is a necessary prerequisite for LCR to be more effective than EPOR. As well, other things being equal, any regulatory body should consider the long-term credibility and effectiveness of an EPOR mandate. To mitigate banks' risk-shifting incentives requires maintenance of higher capital requirements under EPOR. Capital requirements create distortions in the efficient allocation of credit. These distortions are unneccessary in the case where enough (uninsured) creditors believe their funds are at risk of loss because (i) they have sufficient information regarding the nature of the bank's portfolio, and (ii) the closure regime is credible.

Finally, this paper has identified conditions under which EPOR can become more effective: namely, whenever the meta-regulator can convince uninsured depositors that it will liquidate ex post. This is more likely as the shadow price of raising government funds increases, because then the meta-regulator gets tougher and is more likely to divert resolution costs to the private sector.

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Appendix

A.1 Estimation procedure for determining ex ante expected welfare

This section describes the procedure for determining ex ante expected welfare for all possible $\omega \in [0, 0.5]$. First, fix the capital ratio and then estimate the state-contingent welfare $W(\mu, \omega)$ for each possible realization of μ in the event space $[\underline{\mu}, \overline{\mu}]$. The location of μ relative to ω affects the outcome, leading to three possible cases:

Case (i): disintermediation, due to μ being very low

If $\omega > max(\rho(\mu), \rho(0))$, the bank would exit, leading to welfare of $1 + \omega$.

Case (ii): risky intermediation, due to higher μ and/or low ω.

If $\rho(\mu) > max(\rho(0), \omega)$, then the bank would risk-shift. The resulting expected welfare would be

$$E[W(\mu, \omega)] = \int_{A_C}^{2\mu} A \frac{1}{2\mu} dA + \int_{A_M}^{A_C} \{[1 + \theta(1 - \omega)]A - \theta A_0\} \frac{1}{2\mu} dA$$
$$+ \int_0^{A_M} \{\lambda A \left[1 + \frac{\theta\phi}{A_0}\right] - \theta A_0\} \frac{1}{2\mu} dA.$$

The first integral measures the expected welfare over the region where the bank is successful. The second measures the expected welfare over the region where the bank fails and is resolved by liquidation. The third integral measures the expected welfare over the region where the bank fails and is merged.[1]

Case (iii): riskless intermediation

If $\rho(0) > \max(\omega, \rho(\mu))$, then the bank will choose zero risk but also still engage in qualitative asset transformation. In general, this is the best-case scenario for a regulator. There is no possibility of failure if $v = 0$, and thus expected welfare is μ.

This determines the expected welfare for a particular bank type, μ, when there is a capital requirement, ω, in place. Keeping ω fixed, the bank type is varied from the lower bound, $\underline{\mu} = 0.5$, to the upper bound, $\overline{\mu}$. Taking the unweighted average (or expected value) of these type-contingent expected welfare values results in a measure of ex ante expected welfare for a particular capital requirement (an approximation of equation (10)).

The process is repeated for other choices of the policy variable, ω, leading to a schedule of the ex ante expected welfare, $E_\mu[W(\omega)])$, for a particular parameterization set $\{\phi, \lambda, \theta\}$. The optimal choice, ω^*, is the maximum over the interval, $\omega \in [0, 0.5]$.

[1] If $1 - \lambda < \omega$, there would be no possibility of a merger, and thus the measure for the second integral would be zero.

A.2 Proofs of lemmata and propositions in the main text

Proof of Lemma 1

Given the uninsured deposit rate:

$$R = \frac{\mu + v - \sqrt{(\mu+v)^2 - (2-\lambda)(\lambda(\mu-v)^2 + 4v)}}{2-\lambda}.$$

Define $X = (u+v)^2 - (2-\lambda)(\lambda(u-v)^2 - 4v)$. Then, $dR/dv \geq 0$ whenever

$$X^{\frac{1}{2}} - \mu(3-\lambda) + v(1-\lambda) + 2(2-\lambda) > 0,$$

or

$$X^{\frac{1}{2}} > \mu(3-\lambda) - v(1-\lambda) - 2(2-\lambda);$$

however, $v > \mu - 1$ (or $v - 1 > \mu$) for the bank to experience any risk of loss. Thus,

$$(v-1)(3-\lambda) - v(1-\lambda) - 2(2-\lambda) > \mu(3-\lambda) - v(1-\lambda) - 2(2-\lambda)$$

must hold. Proving $dR/dv \geq 0$, it is sufficient to show that

$$X^{\frac{1}{2}} > (v-1)(3-\lambda) - v(1-\lambda) - 2(2-\lambda) = 2(v-2) + 3(\lambda-1),$$

which holds unambiguously if $v < 2$, since the left-hand side is negative, while X must be positive for the interest rate to be defined. Otherwise, if $v > 2$, the right-hand side can be positive. Given the rule for inequalities (if $X^{\frac{1}{2}} > B$ where $B \geq 0$, then $X > B^2$), this condition is rewritten as:

$$(u+v)^2 - (2-\lambda)(\lambda(u-v)^2 - 4v) > (2(v-2) + 3(\lambda-1))^2.$$

Suppose $\lambda = 0$; then, this condition reduces to

$$(\mu+v)^2 - 8v > 4(v-2)^2 + 12(v-2)(\lambda-1) + 9(\lambda-1)^2,$$

which, given $\mu > v$, can be rewritten as

$$4v^2 - 8v - 4v^2 + 16v > 16 + 12 - 24 + 9,$$

or $v > 13/8$, which holds whenever $v > 2$. Consider $\lambda = 1$; then, the main condition reduces to

$$(\mu+v)^2 - (\mu-v)^2 - 4v > 4(v-2)^2,$$

or, given μ,

$$4v^2 - 8v - 4v^2 + 16v > 16,$$

or $v > 2$. Take any $\lambda \in [0,1]$; the minimum necessary v to ensure that dR/dv is non-decreasing in v is always less than 2.

Lemma 2 *Assume that $\lambda = 1$. The expected return for the bank is either maximized at $v = 0$ or $v = \mu$ when: (i) there is an all-merger policy, and (ii) there is an unregulated banking economy.*

Proof of Lemma 2

To show that the expected return of the bank is maximized at one of the end points, it is sufficient to show that the function is non-concave on the interval $v \in [\mu - A_C(v), \mu]$. If so, then, given that there is no risk of failure for $v \leq \mu - A_C(v)$, $\rho(\mu - A_C(v)) = \rho(0)$, and $v = 0$ will be the optimum if $\rho(0) > \rho(\mu)$. Otherwise, $v = \mu$ is the maximum. Given the tractability of the problem, this lemma highlights two extreme cases. In case (i), $R(v) = 1$, $\forall v$, and $A_c = 1/(1-\omega)$. This simplifies the exercise, since there is no indirect effect of v on R. The expected return to the bank is:

$$\rho = \int_{A_c}^{\mu+v} (A - A_C)\frac{1}{2v}dA = \frac{(\mu - A_C)^2}{4v} + \frac{\mu}{2} + \frac{v}{4} - \frac{A_C}{2}.$$

Taking first and second derivatives with respect to ρ:

$$\frac{\partial \rho}{\partial v} = \frac{A_C(A_C - 2) - \mu(\mu - 2)}{4v^2} + \frac{1}{4},$$

$$\frac{\partial^2 \rho}{\partial v^2} = -\frac{2(A_C(A_C - 2) - \mu(\mu - 2))}{4v^3}.$$

The second derivative is unambiguously positive for $\mu > 2$, since the first term in the numerator is negative.[2] The implication is that the return function of v is non-concave. Hence, one needs only to evaluate it at $v = 0$ and $v = \mu$, given that these are the boundaries of choice for v. If $\mu < 2$, then the return function will still be convex, provided $A_C(A_C - 2) - \mu(\mu - 2) \geq 0$. This condition can be reduced to $\mu \geq A_c$. Finally, note that if $A_C(A_C - 2) - \mu(\mu - 2)) < 0$, then the first derivative is strictly positive for all v. Hence, the maximum choice would be $v = \mu$.

In case (ii), $R(v)$ varies with v, but, without deposit insurance or supervision, $A_0 = R(v)$. The expected return to the bank is

$$\rho(v) = \int_{R}^{\mu+v} (A - R)\frac{1}{2v}dA = \frac{(\mu - R)^2}{4v} + \frac{\mu}{2} + \frac{v}{4} - \frac{R}{2}.$$

The second derivative simplifies to:

$$\rho''(v) = \frac{(\mu - r)^2}{8v^3} + \frac{1}{2v^2}\left[[2(\mu - R)R' + v(R')^2 + v(R - v - \mu)R''\right].$$

The first term is positive; the last term within large brackets is negative when $v > \mu + R$. Given $R' > 0$, the sign of this derivative is unambiguously positive if $R'' \leq 0$. Likewise, if, as v increases, R' increases (implying $R'' > 0$) but R'' decreases (implying $R''' < 0$), then the sign will be negative. An example is $\lambda = 1$, implying that $R(v) = \mu + v - 2\sqrt{v(\mu - 1)}$.

[2]This is provided that $\omega < 0.5$. If $\omega \geq 0.5$, then the first derivative is negative, implying a corner optimum of zero risk.

Proof of Proposition 1

From Lemma 2, the bank's return function is non-concave or strictly decreasing on the interval $v \in [\mu - R, \mu]$. Therefore, examining the expected return to the bank when $v = 0$ and $v = \mu$ shows that risk-shifting is not optimal when $\rho(\mu) < \rho(0)$, or:

$$\mu - R + \frac{R^2}{4\mu} \leq \mu - 1,$$

or

$$R^2 \leq 4\mu(R - 1).$$

For risk-shifting to even be rational, however, $\rho(\mu) \geq 0$, which implies that $R^2 \geq 4\mu(R - \mu)$. Hence, for zero risk to dominate risk-shifting over the region where risk-shifting is rational, $\mu \geq 1$. For part (ii), the interest rate for uninsured depositors does not exist when $\mu < 1$. Evaluating the uninsured deposit rate where $v = \mu$ reduces it to:

$$R(\mu) = \frac{2\mu - \sqrt{4\mu^2 - (2-\lambda)4\mu}}{2 - \lambda} = \frac{2\mu - 2\sqrt{\mu(\mu + \lambda - 2)}}{2 - \lambda}.$$

This function does not exist if $\mu + \lambda - 2 < 0$. In fact, for $\mu = 2 - \lambda$, this function is at its maximum of 2. Given that $\lambda \in [0, 1]$, this condition reduces to $\mu \geq 1$ as being necessary for the existence of this interest rate. Hence, there is no gambling for resurrection.

To prove part (iii), notice that all bank types with $\mu \geq 1$ lend out \$1 of funds and get back more than at the next best alternative, which is the risk-free market. These funds are received risk-free, since banks choose zero risk due to uninsured deposit market discipline. If the banks choose the risk-free market instead, then lending a dollar results in a dollar returned. Meanwhile, all banks of type $\mu < 1$ will not lend out risk-free on their loan portfolio, since this results in a negative return. Banks could choose to lend out with maximal risk, but result ('ii) shows that gambling for resurrection is not optimal for a bank of this type. Instead, banks accept \$1 of deposits and lend out at the risk-free rate in the alternative market. In summary, there is neither disintermediation associated with banks of type $\mu \geq 1$ nor gambling by banks of type $\mu < 1$ in equilibrium.

Proof of Proposition 2

The bank will choose $v = 0$ if $\rho(\mu) - \omega \leq \rho(0) - \omega$, or:

$$\frac{1}{4\mu}\left[4\mu^2 - A_c^2\right] - \frac{A_0}{2\mu}\left[2\mu - A_c\right] \leq \mu - 1,$$

or

$$A_0^2 + 4(A_0 - 1)(1 - \omega)^2 - 2A_0^2(1 - \omega) \geq 0.$$

Suppose $A_0 = 1$; then, this condition holds whenever $\omega \geq \frac{1}{2}$. Suppose $A_0 > 1$; then, there exists a $\omega < \frac{1}{2}$ such that this condition holds. Since $1 - \omega > \frac{1}{2}$, this implies that, if

$$A_0^2 + 4(A_0 - 1)(1 - \omega)^2 - 2A_0^2(1 - \omega) > A_0^2 + 4(A_0 - 1)(0.5)^2 - 2A_0^2(0.5),$$

but the right-hand side of this inequality is positive whenever $A_0 > 1$.

Next, suppose that $\omega > 1 - \lambda$ (which is possible for all $\lambda < 0.5$); then, no mergers are possible. This implies that the interest rate on uninsured deposits is a solution to (17). This equation can be defined implicitly as F:

$$\lambda(1-\phi)R^2 + [\lambda\phi + 2(1-\omega)^2[2\mu - (1-\phi)]]R - 2(1-\omega)^2(\phi + 2\mu) \equiv F = 0.$$

Differentiation shows that $F_R > 0$ and $F_\omega < 0$ if $\mu > A_0$. By the implicit function theorem, $dR/d\omega > 0$. Therefore, an increase in ω will lead to an increase in A_0, ultimately leading to zero risk, immediately pushing A_0. This must occur no later than $\omega = 0.5$.

Proof of Proposition 3

The first part of this proposition can be found by simply comparing the difference between the merger points. $A^* < A_M$ when:

$$\theta(1-\lambda-\omega)\phi + \theta(1-\omega)(1-\phi)R < A_0 + \theta(1-\omega)A_0 - \lambda A_0 - \lambda\theta\phi,$$

or $0 < (1-\lambda)A_0$. The second result is found by differentiation of A^* with respect to θ:

$$\frac{\partial A^*}{\partial \theta} = \frac{(1-\phi)RD - \theta(1-\phi)R[(1+\omega) - \lambda\phi/A_0]}{(D^2)},$$

where $D = 1 + \theta(1-\omega) - \lambda - \lambda\theta\phi/A_0$. This partial derivative is positive when $D - \theta(1 + \omega) + \theta\lambda\phi/A_0 = 1 + \lambda > 0$.